

## Article

# Accelerometer and self-reported measures of sedentary behaviour and associations with adiposity in UK youth

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1 Title: Accelerometer and self-reported measures of sedentary behaviour and  
2 associations with adiposity in UK youth.

3

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17

18 **Running title:** Sedentary time, screen time, and adiposity

19 **Keywords:** Youth; sedentary time; screen time; adiposity; measurement.

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25

26    **Abstract**

27

28    This study used accelerometer and self-report measures of overall sedentary time (ST)  
29    and screen time behaviours to examine their respective associations with adiposity  
30    among UK youth. Participants (Year groups 5, 8, and 10;  $n=292$ , 148 girls) wore the  
31    SenseWear Armband Mini accelerometer for eight days and completed the Youth  
32    Activity Profile, an online report tool designed to estimate physical activity and ST.  
33    Stature, body mass and waist circumference were measured to classify adiposity  
34    outcomes (overweight/obese and central obesity). One-way between groups ANOVA  
35    and adjusted linear, logistic and multinomial logistic regression analyses were  
36    conducted. There was a significant main effect of age on total ST across the whole  
37    week ( $F(2, 289)=41.64$ ,  $p\leq 0.001$ ). ST increased monotonically across Year 5  
38    ( $581.09\pm 107.81 \text{ min}\cdot\text{d}^{-1}$ ), 8 ( $671.96\pm 112.59 \text{ min}\cdot\text{d}^{-1}$ ) and 10 ( $725.80\pm 115.20 \text{ min}\cdot\text{d}^{-1}$ ),  
39    and all pairwise comparisons were significant at  $p\leq 0.001$ . A steep age-related gradient  
40    to mobile phone use was present ( $p\leq 0.001$ ). ST was positively associated with  
41    adiposity outcomes independent of moderate-to-vigorous intensity physical activity  
42    (MVPA;  $p\leq 0.001$ ). Engaging in >3 hours of video gaming daily was positively  
43    associated with central obesity ( $OR=2.12$ ,  $p\leq 0.05$ ) but not after adjustment for MVPA.  
44    Results further demonstrate the importance of reducing overall ST to maintain healthy  
45    weight status among UK youth.

46

47    **Keywords:** Youth; sedentary time; screen time; adiposity; obesity; measurement

## 48    **Introduction**

49

50    There is considerable public health interest in understanding the correlates and health  
51    implications of sedentary behaviour (i.e., activities that involve sitting or reclining  
52    while expending little energy) and standardised approaches and definitions have been  
53    proposed to advance this work (Tremblay et al., 2017). The issue is germane to all  
54    segments of the population, but there are unique considerations and challenges when  
55    studying this behaviour in youth (Welk and Kim, 2016). Studies have documented that  
56    sedentary behaviour is associated with increased risk of poor health among youth,  
57    including adiposity (Marshall & Ramirez, 2011; Saunders, Chaput, & Tremblay,  
58    2014); however, results depend on the nature of the study design and how sedentary  
59    behaviour is measured (Welk and Kim, 2016). Recent evidence also suggests that the  
60    sedentary behaviour and adiposity relationship is partly mediated by cardiorespiratory  
61    fitness (Santos et al., 2018). Thus, the associations are more complex than previously  
62    thought.

63

64    Part of the challenge is due to the many different forms of sedentary behaviour. These  
65    include educational activities such as homework, travelling passively (i.e., motorized  
66    transport), seated hobbies (e.g., reading and talking with friends), and screen time  
67    behaviours (e.g., TV viewing, video games, etc.), with screen time behaviours being  
68    the most common form of leisure-time sedentary behaviours among youth (Biddle,  
69    Marshall, Gorely & Cameron, 2009; Kenney & Gortmaker, 2017). Prominent reviews  
70    have highlighted the high overall prevalence of sedentary behaviours, especially  
71    during leisure-time (Arundell, Fletcher, Salmon, Veitch & Hinkley, 2016), but less is  
72    known about the breakdown of the different types of sedentary behaviour.

73

74 In the UK, many youths spend more than 2 hours per day engaged in screen time  
75 behaviours (Coombs & Stamatakis, 2015; Sandercock, Ogunleye & Voss, 2012).  
76 While current evidence suggests that sedentary time increases with age (Janssen et al.,  
77 2016; Ruiz et al., 2011; Santos et al., 2018), it is unknown whether these age-related  
78 differences are reflected in specific screen time behaviours among UK youth.  
79 Moreover, to date, very few UK studies have used self-reported measures alongside  
80 device-based measures to provide contextual understanding of a range of youth  
81 sedentary behaviours (Coombs & Stamatakis, 2015). The use of parallel measures of  
82 sedentary behaviour and investigation of these sedentary behaviours across age groups  
83 can highlight specific sedentary behaviours during youth that may benefit from age-  
84 targeted interventions.

85

86 Although a positive association between overall screen time and youth adiposity has  
87 been shown (Bai et al., 2016), few studies have examined the influence of specific  
88 types of screen time behaviours on youth adiposity. Indeed, a recent systematic review  
89 of reviews highlighted the limited number of studies reporting data on mobile screen  
90 use in particular (Stiglic & Viner, 2019). Traditionally, time spent watching TV has  
91 been treated as a representative measure of screen time (Eisenmann, Bartee, Smith,  
92 Welk & Fu 2008; Steffen, Dai, Fulton & Labarthe, 2009; Zhang, Wu, Zhou, Lu &  
93 Mao 2016), leading to the consistent finding that youth who watch high levels of TV  
94 are more likely to be overweight or obese (Carson et al., 2016a; Tremblay et al., 2011a;  
95 2011b). However, TV time alone is no longer adequate as a representative measure of  
96 screen time, since other devices (e.g., computers, games consoles, tablets, mobile  
97 phones) have become prominent elements of youth lifestyle (Ofcom, 2017).

98 Therefore, a greater level of specificity is necessary when assessing sedentary  
99 behaviour, and particularly screen time among youth. To address this need, the aims  
100 of this study were to 1) assess age-related differences in youth sedentary time, screen  
101 time behaviours and adiposity, and 2) examine associations between parallel measures  
102 of youth sedentary behaviour (i.e., accelerometer measured sedentary time and self-  
103 reported screen time behaviours) and adiposity.

104

## 105 **Methods**

106

### 107 **Participants**

108

109 Eleven schools (four primary and seven secondary) situated in North West England  
110 were provided with information regarding the study and were invited to participate.  
111 Four primary (100%) and five secondary schools (71%) agreed to take part.  
112 Participating schools received project and consent information and were scheduled for  
113 data collection. Informed parental consent and child assent was obtained from 401  
114 students (209 boys) in Year groups 5 (aged 9 - 10 years,  $n = 133$ ), 8 (aged 12 - 13  
115 years,  $n = 132$ ), and 10 (aged 14 - 15 years,  $n = 136$ ). Ethical approval was granted  
116 from Liverpool John Moores Research Ethics Committee (14/SPS/012). A financial  
117 incentive of £700 was provided to each participating school and each participant  
118 received a £10 retail voucher for taking part. Data collection took place on school sites  
119 during school-term time between March and July 2017.

120

### 121 **Measures**

122

123 *Adiposity*

124

125 Trained researchers measured stature to the nearest 0.1 cm using a portable  
126 stadiometer (Leicester Height Measure, Seca, Birmingham, UK), and body mass to  
127 the nearest 0.1 kg using the same calibrated scales (Seca, Birmingham, UK). Body  
128 mass index (BMI) was calculated from stature and body mass ( $\text{kg/m}^2$ ), and BMI z-  
129 scores were assigned to each participant (Cole, Freeman & Preece, 1995). Age- and  
130 gender-specific BMI cut-points were used for normal weight or overweight/obese  
131 classifications (Cole, Bellizzi, Flegal & Dietz 2000). Waist circumference was  
132 measured at the midpoint between the bottom rib and the iliac crest to the nearest 0.1  
133 cm using a non-elastic measuring tape (Seca, Birmingham, UK). Waist-to-height ratio  
134 (WHtR) was used as a measure of central obesity, with a  $\text{WHtR} \geq 0.5$  indicating the  
135 presence of central obesity (McCarthy & Ashwell, 2006; Mokha et al., 2010).

136

137 *Device-based sedentary time*

138

139 Each participant wore a SenseWear Armband Mini (SWA) (BodyMedia, Inc.,  
140 Pittsburgh, PA) wireless pattern-recognition device on their upper non-dominant arm.  
141 The SWA estimates energy expenditure by integrating data from multiple sources,  
142 including a bi-axial accelerometer, physiological sensors (e.g. capturing heat flux and  
143 galvanic skin response), and demographic information (i.e., the wearer's age, gender,  
144 and weight) (Arvidsson, Slinde, Larsson & Hulthén, 2007). The SWA has been  
145 validated in youth (Calabro, Welk & Eisenmann, 2009; van Loo et al., 2017), and has  
146 been shown to provide accurate estimates of sedentary time (Ridgers, Hnatiuk,  
147 Vincent, Timperio, Barnett & Salmon, 2016). A key advantage of the SWA for field-



148 based research is its ability to accurately detect non-wear time. The SWA is able to  
149 detect whether the device is in contact with skin, which provides a more refined  
150 estimate of non-wear time and consequently reduces the error within the measure of  
151 sedentary time (Andre et al., 2006).

152

153 The SWA devices were initialized with default 1-minute epochs using the SenseWear  
154 Pro v.8.0 software. Each participant was provided with verbal and written instructions  
155 detailing how to wear the SWA. They were asked to wear the device continuously for  
156 8-days, removing only for water-based activities and contact sports. On return of the  
157 SWA devices, data were downloaded using the SenseWear Pro software (v.8.0), and  
158 files were converted to .xls format to enable initial data screening. Subsequent data  
159 processing was conducted in R (R Core Team, 2017) using custom-written code. To  
160 be included in the analysis, participants needed to wear the SWA for a minimum of  
161 960 minutes per day on at least 3 days (Fairclough et al., 2017; Rowlands et al., 2018;  
162 Slootmaker et al., 2009). SWA data were expressed as METs, which were then  
163 converted to minutes of sedentary time and moderate-to-vigorous intensity physical  
164 activity (MVPA) during waking hours (7am to 11pm) using age- and gender-specific  
165 thresholds (Welk, Morrow & Saint-Maurice, 2017).

166

#### 167 *Self-reported screen time*

168

169 Participants completed an online physical activity and sedentary behaviour survey  
170 under the supervision of researchers and teachers. We used a UK-specific version of  
171 the Youth Activity Profile (YAP). The YAP is a 7-day recall tool that consists of 15  
172 items relating to in-school activity (five items), out-of-school physical activity (five

173 items), and sedentary behaviours (five items). Among US youth, YAP estimates of  
174 weekly physical activity and sedentary time have previously demonstrated agreement  
175 with estimates derived from objective monitors (Saint-Maurice & Welk, 2015; Saint-  
176 Maurice, Kim, Hibbing, Oh, Perna, & Welk, 2017). Participants answered each item  
177 using a 5-point Likert scale representing the frequency of the behaviour. A critical  
178 aspect of the items that addressed sedentary behaviour was the presence of separate  
179 items inquiring about time spent in the following screen time behaviours: watching  
180 TV, playing video games, using computers or tablets, and using a mobile/cell phone.  
181 Participants were asked to indicate how much time in the previous 7-days they had  
182 spent engaging in each screen time behaviour. The survey does not distinguish  
183 between school and leisure screen time. Response choices were: no use, less than 1-  
184 hour per day, 1-2 hours per day, 2-3 hours per day, and more than 3 hours per day.  
185 Responses were clustered, so we collapsed the responses, and created two  
186 dichotomized variables for each screen time behaviour representing > 2 hours per day  
187 and > 3 hours per day engagement. Only data from these four questions are reported  
188 in this study. On completion of the survey, researchers checked the responses with the  
189 participants before they were submitted. Each participant's electronic YAP responses  
190 were collated in school- and class-specific .csv files, which were subsequently cleaned  
191 and merged with the other data.

192

### 193 *Covariates*

194

195 Potential confounding factors were selected *a priori* based on previous evidence  
196 (Coombs, Shelton, Rowlands & Stamatakis, 2013; LeBlanc et al., 2016; Saunders &  
197 Vallance, 2017). Participant age, gender and home postcode were self-reported. Area-

level deprivation was calculated from home postcodes using the 2015 Indices of Multiple Deprivation (IMD; Department for Communities and Local Government, 2015). The IMD is a UK Government measure comprising seven areas of deprivation including income, employment, health, education, housing, environment and crime. Home postcodes were entered into the GeoConvert (<http://geoconvert.mimas.ac.uk/>) application (MIMAS, 2018) to generate deprivation scores. Higher deprivation scores represented higher deprivation. Missing responses were imputed with the variable mean score ( $n = 26$ ) to prevent further data loss. This imputation approach has been used previously in physical activity studies involving children (Corder et al., 2010). MVPA measured from the SWA was also included as a covariate as MVPA is known to be associated with adiposity in youth (Schwarzfischer et al., 2017).

209

## Analyses

211

All analyses were conducted using SPSS v. 24 (SPSS Inc; Chicago, IL) and statistical significance was set at  $p \leq 0.05$ . Descriptive statistics were calculated for all measured variables.

215

Research aim 1 was to assess age-related differences in youth sedentary time, screen time behaviours and adiposity. To address this aim, a one-way between groups analysis of variance (ANOVA) with Bonferroni post-hoc test was performed to examine differences in device-based measured sedentary time between Year groups. Multinomial logistic regression analyses examined differences in adiposity outcomes and self-reported screen time behaviours between Year groups. The Year 5 group was

222 chosen as the reference category. Analyses were adjusted for gender, deprivation and  
223 MVPA.

224

225 Research aim 2 was to examine associations between parallel measures of youth  
226 sedentary behaviour (i.e., accelerometer measured sedentary time and self-reported  
227 screen time behaviours) and adiposity. To address this aim, linear and logistic  
228 regression analyses assessed associations between device measured sedentary time  
229 and adiposity outcomes, and self-reported screen time behaviours and adiposity  
230 outcomes, respectively. Analyses were adjusted for gender, Year group, deprivation,  
231 and MVPA.

232

## 233 **Results**

234

235 Forty-nine participants were absent on data collection days or did not provide all  
236 required data for the analyses, which meant YAP, IMD, and SWA data were available  
237 from 353 participants. Fifty-two participants did not achieve the SWA wear time  
238 criteria, and a further nine participants had incomplete questionnaire data. These  
239 participants were subsequently removed from analyses, which resulted in a final  
240 analytical sample of 292 participants (148 girls) (72.8% response rate). The  
241 descriptive characteristics of the sample are presented in Table 1.

242

243 [TABLE 1 NEAR HERE]

244

### 245 *Research aim 1*

246

247 Daily SWA wear time (mean  $\pm$  SD) for Year 5, 8 and 10 children was  $1225.10 \pm$   
 248  $150.44 \text{ min}\cdot\text{d}^{-1}$ ,  $1271.84 \pm 126.70 \text{ min}\cdot\text{d}^{-1}$ , and  $1289.45 \pm 110.86 \text{ min}\cdot\text{d}^{-1}$ ,  
 249 respectively. There was a significant main effect of age on total sedentary time across  
 250 the whole week ( $F(2, 289) = 41.64, p < 0.001$ ). Bonferroni post-hoc testing showed a  
 251 monotonic increase in sedentary time with increasing age, and all pairwise differences  
 252 were significant with  $p < 0.001$ . The most dramatic increase occurred between Year 5  
 253 ( $581.09 \pm 107.81 \text{ min}\cdot\text{d}^{-1}$ ) and Year 8 ( $671.96 \pm 112.59 \text{ min}\cdot\text{d}^{-1}$ ), whereas the increase  
 254 was more modest between Year 8 and Year 10 ( $725.80 \pm 115.20 \text{ min}\cdot\text{d}^{-1}$ ).

256 Compared to Year 5 children, Year 10 children were more likely to engage in  $> 3$   
 257 hours of video gaming (Odds Ratio, OR = 3.34;  $p \leq 0.05$ ; Table 2),  $> 2$  hours of  
 258 computer/tablet time (OR = 5.02;  $p \leq 0.001$ ),  $> 3$  hours of computer/tablet time (OR  
 259 = 29.81;  $p \leq 0.001$ ),  $> 2$  hours of mobile phone use (OR = 11.73;  $p \leq 0.001$ ), and  $> 3$   
 260 hours of mobile phone use (OR = 10.71;  $p \leq 0.001$ ). Compared to Year 5 children,  
 261 Year 8 children were more likely to engage in  $> 2$  hours of mobile phone use (OR =  
 262 2.90;  $p \leq 0.001$ ), and  $> 3$  hours of mobile phone use (OR = 2.54;  $p \leq 0.01$ ).

264 [TABLE 2 NEAR HERE]

## 266 *Research aim 2*

268 Adjusted linear regression analyses revealed a positive association between sedentary  
 269 time and BMI z-score ( $B = 0.01, p \leq 0.001$ ; Table 3) and waist circumference ( $B =$   
 270  $0.03, p \leq 0.001$ ). Associations between sedentary time and BMI z-score and waist  
 271 circumference remained significant at  $p \leq 0.01$  after adjustment for MVPA.

272

273 [TABLE 3 NEAR HERE]

274

275 Table 4 presents OR for associations between screen time behaviours and adiposity.  
276 Children who reported engaging in more than 3 hours of video gaming daily (OR =  
277 2.28, 95% CI = 1.04 – 5.02) were more likely to be classified as centrally obese  
278 compared with children who reported engaging in less than 3 hours of video gaming  
279 daily, respectively. However, the association was attenuated after adjustment for  
280 MVPA.

281

282 [TABLE 4 NEAR HERE]

283

## 284 **Discussion**

285

286 This study represents the first in the UK to use device-based and self-report measures  
287 of youth sedentary behaviour to assess age-related differences and associations with  
288 adiposity. The study revealed significant age-related differences in device measured  
289 sedentary time and self-reported computer/tablet time and mobile phone use. Device  
290 measured sedentary time was positively associated with adiposity independent of  
291 MVPA, but none of the self-reported screen time behaviours were associated with  
292 adiposity outcomes after adjustment for MVPA.

293

294 Consistent with prior UK (Janssen et al., 2016) and European research (Ruiz et al.,  
295 2011) this study evidenced an age-related gradient to device measured sedentary time.  
296 Here we extend beyond earlier studies by revealing an age-related gradient to some

297 self-reported screen time behaviours, namely computer/tablet time and mobile phone  
298 use. One possible explanation for this finding is that adolescents often have more  
299 autonomy on how they spend their free time (Haberstick et al., 2014) in comparison  
300 to younger children, and this unstructured time is often spent engaged in video gaming,  
301 computer/tablet time and/or mobile phone use. Moreover, adolescents may spend  
302 more time on computers in their leisure-time compared to younger children because  
303 they are completing homework (Sheldrick et al., 2018). Such productive screen time  
304 behaviours can be perceived as positive for development and wellbeing (e.g.,  
305 academic attainment, school functioning; Carson et al., 2016b), and may not  
306 necessarily displace more ‘healthy behaviours’ such as physical activity (Sheldrick et  
307 al., 2018). Further work exploring age-related variability in screen time behaviours  
308 will help inform the timing and targeting of sedentary behaviour and wellbeing  
309 interventions. Moreover, although age-related differences were observed for device-  
310 based and self-report measures of sedentary behaviour, we found no statistically  
311 significant differences in adiposity outcomes between young and older youth, which  
312 is consistent with previously reported English population level data (Conolly, 2016).

313

314 In this study, device measured sedentary time was positively associated with adiposity  
315 in UK youth. This finding is consistent with a recent systematic review of reviews  
316 (Stiglic & Viner, 2019), and some individual studies (De Bourdeaudhuij et al., 2013),  
317 but not all (Atkin et al., 2013; Marques et al., 2016). Notably, the strength of  
318 associations between sedentary time and adiposity outcomes were small, which is  
319 consistent with the findings of a 2017 review of reviews and analysis of causality  
320 (Biddle, García Bengoechea, Wiesner, 2017). Such modest associations may be  
321 attributable to the varied methodological approaches employed. For example, different

322 measurement methods influence the observed strength of association between  
323 sedentary time and youth adiposity. Moreover, the combined effect of sedentary time,  
324 physical activity, dietary behaviour and sleep on adiposity is currently not well  
325 understood (Leech, McNaughton & Timperio, 2014). For example, health enhancing  
326 behaviours (i.e., regular physical activity and healthy food intake) may compensate  
327 for unhealthy behaviours (i.e., high sedentary time) which would offer some  
328 explanation for the inconsistency across the literature (Grgic et al., 2018; Sheldrick et  
329 al., 2018). Further research examining the concurrent effect of sedentary time,  
330 physical activity, diet and sleep behaviour on adiposity in youth is warranted.

331

332 A novel aspect of this study was the examination of associations between a range of  
333 screen time behaviours and youth adiposity. Almost all associations between screen  
334 time behaviours and adiposity were in a positive direction, but few were statistically  
335 significant. Again, this finding may be primarily reflective of the complexity of youth  
336 adiposity but may also be due to the low prevalence of excessive screen time behaviour  
337 when TV viewing was included (> 2 hours daily; 18.90%, 36.20% and 23.40% of Year  
338 5, 8 and 10 youth, respectively) compared to previous European (57.2%-85.8%; Jago  
339 et al., 2008) and US research (29% to 35%; Fulton et al., 2009). Furthermore, the  
340 increased availability of 'on demand' TV options means that youth may also be  
341 watching television programmes online using computers or tablet devices. Such  
342 modes of screen use require further exploration in future studies. Although TV  
343 viewing is currently the most widely studied screen behaviour associated with youth  
344 adiposity (Carson et al., 2016a; Tremblay et al., 2011a), future research should  
345 continue to work towards differentiating the health impact of different screen time



346 behaviours. This is especially the case with video gaming, since playing video games  
347 for more than 3 hours per day in this study was associated with central obesity risk.

348

### 349 *Strengths and limitations*

350

351 This study represents the first in the UK to use device-based and self-reported  
352 measures of total sedentary time and screen time behaviour to assess age-related  
353 differences and associations with adiposity. We considered multiple measures of  
354 adiposity, measured sedentary time using a validated device, and adjusted the analyses  
355 for known confounding factors. There were also limitations in this study. We used  
356 validated measures to assess screen time behaviours, but the data derived from these  
357 self-report measures may have been prone to some forms of measurement error, such  
358 as social desirability bias from participants. To protect against this, surveys were  
359 completed independently under the supervision of researchers and teachers, and  
360 participants verified their responses before submitting. Our self-report measure was  
361 unable to capture whether youth engaged in concurrent sedentary behaviours (i.e.,  
362 screen stacking) which may influence associations with adiposity. The SWA 1-minute  
363 epoch may not have been sensitive enough to capture short episodes of higher intensity  
364 activity and thus may have biased MVPA estimates (Edwardson & Gorely, 2010). The  
365 study design was cross-sectional, and we are therefore unable to determine causality.

366

### 367 **Conclusion**

368

369 This study evidences an age-related gradient to device measured sedentary time and  
370 some self-reported screen time behaviours among UK youth. The results highlight the

371 importance of limiting total sedentary time in youth to reduce risk of adiposity. None  
372 of the self-reported screen time behaviours were associated with adiposity outcomes  
373 after adjustment for MVPA. Given the complexity of youth adiposity it is important  
374 for future research to explore the concurrent effect of a range of lifestyle behaviours  
375 including multiple modes of sedentary behaviour.

376

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378

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383

### 384 **Disclosure statement**

385

386 No potential conflict of interest was reported by the authors.

387

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389

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663 Table 1. Descriptive characteristics of sample

Variable	Year 5 ( <i>n</i> = 93)	Year 8 ( <i>n</i> = 94)	Year 10 ( <i>n</i> = 105)
	Mean (SD) or %	Mean (SD) or %	Mean (SD) or %
Gender			
Boy	50.50	40.40	56.20
Girl	49.50	59.60	43.80
Age (years)	10.18 (0.33)	13.17 (0.34)	15.23 (0.33)
Stature (cm)	141.37 (6.20)	157.16 (9.10)	167.61 (8.59)
Body mass (kg)	36.08 (7.81)	51.04 (11.44)	63.26 (12.15)
BMI (kg/m <sup>2</sup> )	17.93 (2.91)	20.69 (4.62)	22.55 (4.22)
BMI z-score	0.46 (1.08)	-0.12 (8.03)	0.85 (1.13)
Overweight/obese	26.90	27.70	33.30
WC (cm)	64.38 (7.23)	72.61 (9.66)	76.80 (9.83)
WHtR	0.46 (0.05)	0.46 (0.07)	0.46 (0.06)
WHtR >0.50	15.10	22.30	21.90
Sedentary time (min/day)	581.09 (107.81)	671.96 (112.59)	725.80 (115.20)
MVPA (min/day)	158.50 (70.77)	137.29 (64.77)	138.74 (64.39)
Deprivation score	16.26 (10.20)	20.55 (14.21)	19.63 (13.72)

664 BMI, body mass index; WC, waist circumference; SD, standard deviation; WHtR,  
665 waist-to-height-ratio; MVPA, moderate-to-vigorous physical activity.

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672 Table 2. Multinomial logistic regression associations between Year group and  
673 adiposity outcomes and screen time behaviours.  
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Variable	Year 5	Year 8	Year 10
	Odds ratio (95% CI)	Odds ratio (95% CI)	Odds ratio (95% CI)
Adiposity outcomes			
Overweight/obese	(Ref)	1.37 (0.72 - 2.61)	1.02 (0.53 - 1.95)
Central obesity	(Ref)	0.92 (0.46 - 1.87)	1.20 (0.55 - 2.58)
Screen time behaviours			
TV > 2 hrs/day	(Ref)	0.61 (0.32 - 1.14)	1.13 (0.56 - 2.26)
TV > 3 hrs/day	(Ref)	0.92 (0.31 - 2.66)	0.80 (0.29 - 2.22)
Video > 2 hrs/day	(Ref)	0.58 (0.30 - 1.13)	1.52 (0.77 - 3.03)
Video > 3 hrs/day	(Ref)	0.85 (0.39 - 1.87)	3.34 (1.28 - 8.71) **
Computer > 2 hrs/day	(Ref)	1.58 (0.88 - 2.85)	5.02 (2.43 - 10.40) ***
Computer > 3 hrs/day	(Ref)	1.54 (0.75 - 3.15)	29.81 (3.93 - 46.37) ***
Phone > 2 hrs/day	(Ref)	2.90 (1.60 - 5.26) ***	11.73 (5.81 - 23.69) ***
Phone > 3 hrs/day	(Ref)	2.54 (1.39 - 4.6) **	10.71 (4.50 - 25.47) ***

675 Adjusted for gender, deprivation and MVPA in all analyses; Year 5 group were  
676 reference category; CI, confidence interval; \*\*  $p \leq 0.01$ ; \*\*\*  $p \leq 0.001$ .

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Table 3. Adjusted linear regression associations between device assessed sedentary time and adiposity outcomes.

Variable	Model 1 †				Model 2 ††			
	B (95% CI)	SE	β	p	B (95% CI)	SE	β	p
BMI z-score	0.01 (0.00 – 0.01)	0.00	0.19	0.005	0.01 (0.00 – 0.01)	0.00	0.21	0.008
Constant	-2.50 (-5.79 - 0.80)	1.68		0.14	-3.32 (-8.09 - 1.44)	2.42		0.17
Waist circumference	0.03 (0.02 - 0.03)	0.00	0.30	>0.001	0.02 (0.01 - 0.03)	0.01	0.22	>0.001
Constant	46.23 (40.10 - 52.35)	3.11		>0.001	54.22 (45.46 - 62.97)	4.45		>0.001

† Analyses adjusted for gender, Year group and deprivation; † Analyses adjusted for gender, Year group, deprivation and MVPA; B, unstandardised β coefficient; β, standardised β coefficient; BMI, body mass index; CI, confidence interval; SE, Standard error.



Table 4. Adjusted logistic regression associations between screen time behaviours and adiposity outcomes.

Variable	Overweight/obese †	Overweight/obese ††	Central obesity †	Central obesity ††
	Odds ratio (95% CI)	Odds ratio (95% CI)	Odds ratio (95% CI)	Odds ratio (95% CI)
TV > 2 hrs/day	1.08 (0.60 - 1.93)	1.10 (0.60 - 2.02)	1.20 (0.62 - 2.29)	1.26 (0.64 - 2.48)
TV > 3 hrs/day	0.65 (0.23 - 1.85)	0.63 (0.21 - 1.88)	0.83 (0.27 - 2.56)	0.81 (0.25 - 2.64)
Video > 2 hrs/day	1.31 (0.72 - 2.38)	1.24 (0.67 - 2.31)	1.64 (0.84 - 3.19)	1.55 (0.78 - 3.08)
Video > 3 hrs/day	1.39 (0.67 - 2.90)	1.21 (0.56 - 2.61)	2.28 (1.04 - 5.02) *	1.99 (0.87 - 4.55)
Computer > 2 hrs/day	1.41 (0.80 - 2.47)	1.27 (0.71 - 2.29)	1.61 (0.86 - 3.01)	1.44 (0.75 - 2.77)
Computer > 3 hrs/day	1.55 (0.76 - 3.17)	1.30 (0.62 - 2.74)	1.66 (0.76 - 3.62)	1.37 (0.61 - 3.07)
Phone > 2 hrs/day	1.45 (0.82 - 2.58)	1.43 (0.79 - 2.58)	1.14 (0.60 - 2.17)	1.12 (0.57 - 2.19)
Phone > 3 hrs/day	1.36 (0.75 - 2.46)	1.25 (0.68 - 2.31)	1.36 (0.70 - 2.63)	1.25 (0.63 - 2.48)

† Adjusted for gender, Year group, deprivation; †† Adjusted for gender, Year group, deprivation and MVPA; Year 10 children were the reference group; CI, confidence interval; \*  $p \leq 0.05$ .

